so as to bring them up to date. A striking instance of this is afforded by the one on giraffes, which takes no notice of the new forms described in "Animal Life" for 1903, and in the *Proceedings* of the Zoological Society for the present year. A minor instance is the statement (p. 212) that the aard-vark is represented in the exhibition galleries of the Natural History Museum by a specimen mounted in 1841, that specimen having been removed considerably more than a year ago, and replaced by a new one. Again, on p. 56, Mr. Renshaw repeats his statement that an antelope skull in the Museum of the Royal College of Surgeons is that of the extinct blaauwbok, whereas Mr. O. Thomas has expressly stated in the *Field* that it pertains to the roan antelope. If the author adheres to his original view, he should at least have attempted to refute the statement of an expert like Mr. Thomas.

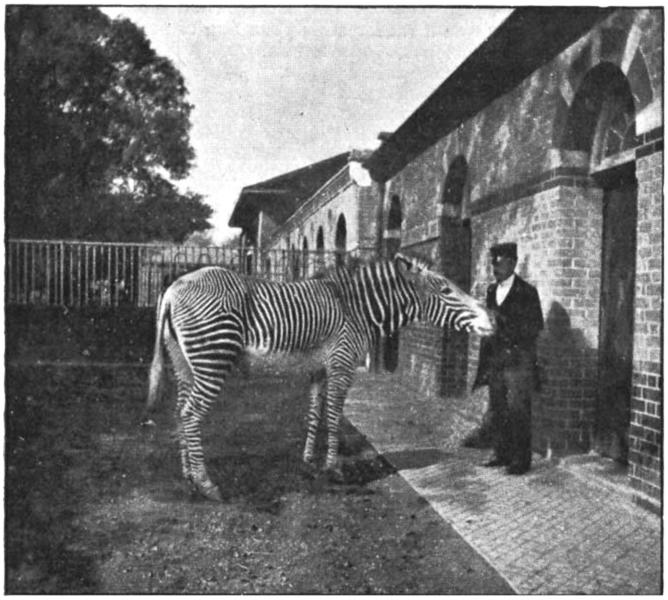

FIG. 1.—A Grévy's Zebra. From Renshaw's "Natural History Essays."

A further instance of what may be called "opinionism" on the part of an amateur is afforded by the case of the quagga in the Natural History Museum, which Mr. Renshaw, in opposition to the museum authorities, believes to be one which was brought to London in 1831. The evidence indicates, on the contrary, that this specimen is without doubt one received by the Zoological Society in September, 1858, which died, or was killed, in June, 1864, and was acquired by the museum in July of the same year, as is indicated by its register number (64.7.2.3). Equally erroneous, unfortunately, is the statement on p. 191 that the Amsterdam quagga was a Knowsley Menagerie specimen, as has been pointed out in a recent issue of the *P.Z.S.* *Per contra,* Mr. Renshaw is to be credited with pointing out that the quagga depicted in "Wood's Natural History" is one of the specimens living in the "Zoo" during the 'sixties, since the figure indicates an animal clearly identical with those represented in the "Knowsley Menagerie," and thus serves to identify the quaggas of the 'sixties with those figured in older works, which have been thought to be different. The reference to a statement made in 1801 as to the protective nature of the markings of the zebra (p. 165) is likewise a point on which the author is to be congratulated.

Reverting to errors, we may direct attention to the misappropriation of the name *Felis pardina* (p. 19) to the ocelot, of which the proper title is *F. pardalis*, *pardina* being the appellation of the Spanish lynx. In popular works the use of scientific names should, in our opinion, be mostly avoided, but if they are used they should be correct; a transposition of names like the above is every bit as bad as calling a lion a tiger! Another example of the necessity for care in the employment of scientific names in works of this nature occurs on p. 133. In one sentence on that page we find the name *Rhinoceros antiquitatis*, and later on the title "woolly rhinoceros," but there is nothing to indicate to the uninitiated that these denote one and the same animal.

If only the author had paid a little more attention to the revision of his articles he might have converted a very interesting volume into a really valuable record of the past history of several extinct and waning forms.

R. L.

DEVELOPMENTS OF THREE-COLOUR PHOTOGRAPHIC PROCESSES.[1]

II.

HAVING obtained the three colour records it remains to use them for locating the colour in the production of the final print. If the coloured lights are to be added, as in Ives's chromoscope, then a transparency is made from each colour record (which is, of course, a negative), and each transparency is made to furnish light of a similar colour to that of which it is the record. If the colours are to be superposed, as when they are printed one over the other, or when coloured transparencies are made and superposed in the method of making coloured lantern-slides, then a complementary colour to that of each record must be used, because the absorptions are added instead of the lights. In the chromoscope the colours are in the form of screens; they remain in the instrument, and therefore are provided once for all. In the other cases they are stains or inks, and an amount is used up in the production of each print; they are therefore used in quantity. In the choice of inks and stains, the perfection of colour is only a matter of degree, and those colours that most nearly approach perfection may not be suitable otherwise. The best colours may be (and in some cases are) fugitive, so that for practical purposes an inferior colour has to be used. If the colour is perceptibly different from the theoretical tint, then the colour records must be adjusted to make the best of the available colours. When the colours are superposed, as in printing on paper, at least two of the three inks must be made of transparent colours, or obviously the top colour would hide those beneath. This last matter is, as Hübl remarks, one of the most important difficulties in trichromatic work, and, he adds, the colour last printed will always predominate over those previously applied. Hübl, in his treatise, describes how to select the inks by means of his circular spectrum colour scheme, and how to mitigate the errors due to the defects of the selected colours, chiefly by retouching and by setting off one defect against another. The inks may be selected also by the use of Abney colour sensitometers, or by spectroscopic methods, but it is not sufficient to judge of the colour by the eye alone. It is necessary that the colours shall not only look right, but that they shall be right when analysed spectroscopically. Each colour is used, not so much for its own sake, as to give the proper tints when the light it reflects or transmits is mixed with the light from the other colours.

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[1] "The Water-Colour Drawings of J. M. W. Turner, R.A., in the National Gallery." By T. A. Cook. Pp. vi+86 and 58 plates. (London: Cassell and Co., Ltd., 1904.) Price 3 guineas net.

"Three-Colour Photography." By A. F. von Hubl. Translated by H. O. Klein. Pp. 148. (London: A. W. Penrose, Ltd., 1904.)

"Photography in Colours." By R. C. Bayley. 2nd edition. Pp. 151. (London: Iliffe, Ltd., 1904.) Price 1*s*. net.

Continued from p. 555.

But supposing that the inks or stains selected were theoretically perfect in colour, and perfectly transparent, so that when superposed the lowest produced its full effect, it still remains to see that each is laid on in its due proportion, for if one is in error the whole will be thrown out, and what should be neutral greys will be tinted with colour. And there is still another difficulty to consider. The gradation produced by the same treatment of a sensitive plate generally becomes more steep as the wave-length of the light used increases. This is certainly the rule, though there may be exceptions to it. Therefore, if the pink, yellow, and blue inks are properly proportioned to give a neutral black where the colours are in full quantity, the greys may be expected to be bluish, and in the lighter colours there may be expected a deficiency of red. To overcome these difficulties, some have sought to use four, or even five, colours instead of three, and others have used a fourth plate with black ink to give the blacks and greys, removing from the plate those parts where pure colours are required. Obviously, the use of additional printing plates is a confession that the three-colour process cannot be worked on the theoretical lines, but such variations as these do not appear to be at all generally adopted.

There are many methods by which the three colours may be brought together to make the final picture. The simplest of all, both theoretically and practically, and at the same time perhaps the most perfect and therefore the most beautiful, appears to be the production of transparencies by the superposition of gelatine reliefs produced from the colour records, each appropriately stained by immersion in a suitable dye solution. There is nothing to regulate the depth of colour to which each relief should be stained but the judgment of the worker, and the fact that the greys and blacks of the original should be untinted by colour in the reproduction. A relief may be more highly coloured by a further immersion in the dye solution, or lightened by immersion in water.

For printing on paper, either the collotype process, lithography, or typographic blocks may be employed. Some very excellent work has been done by the first of these methods, but in both collotype and lithography, as already stated, it is difficult to regulate, to a nicety, the amount of ink applied, and the successful impressions generally form only a small proportion of the whole. The process that is the most used, and that certainly at the present is the most suitable, consists in printing from typographic blocks as ordinary letterpress is printed. The photographic production of blocks from half-tone negatives is practised to so great an extent, and the machinery for letterpress printing is so perfect, that uniformity is more easily secured by this than by other methods. In pointing out the advantages of this process, Colonel Hübl states that it gives a better blending of the colours, and that the inks are not brought into contact with water so that they remain pure, and as the paper remains dry during the printing a better register is secured. But the process has its own defects—Hübl says that "the gradation is limited and incorrect," and that "the final result depends more on the clever work of the retoucher than on the perfection of the photographic negative." This last statement conveys, perhaps, rather an exaggerated view of the facts of the case.

The dots in the impression from a half-tone block are, as is well known, in lines, as determined by the ruling of the screen that is placed in front of the plate when the grained negative is made. Now when lines at regular intervals cross each other at a small angle a pattern is produced known as a "moire" or "watering" effect, from its similarity to the appearance of "watered" silk. The effect can easily be seen by looking through two pieces of muslin superposed with the threads not quite parallel. Two rows of park railings, if near enough, will often show it, the railings in each row being parallel to each other, but not quite parallel to those in the other row. In superposing three impressions from blocks made by means of cross-lined screens, it is important to avoid any approach to parallelism of any set of lines or rows of dots with any other, especially as regards the relative positions of the red and blue impressions, as these are darker than the yellow, and therefore more conspicuous. It is obvious that if the screen used has its crossing lines at right angles, the three impressions will give six sets of lines, and an angle of 30° between each and the next if the angles of crossing are kept equal. Circular lined screens mounted in aluminium cells, so that they can be rotated to any desired angle with precision, are much used in America and are coming into use here. A common method, which is being superseded by the circular screen, is to use two rectangular screens, one of which is ruled at such angles that, by turning it round from back to front, it gives the rulings in the third position. Other methods are sometimes used for the purpose, for the shape of the aperture in the diaphragm affects the character of the dots, and it is possible to use a slit diaphragm and rotate the lens that carries it. But the most notable variation in the preparation of the blocks is to get rid of the lines, or even rows of dots, altogether, by using an irregular grained screen. Of the many attempts that have been made in this direction, the one that seems to offer the greatest promise of success is Wheeler's "metzograph" screen, in which an irregular wavy surface of the glass gives the concentrations of the light required.

There is one matter in connection with three-colour printing by means of half-tone blocks that sometimes presents a difficulty to the minds of those who have a slight acquaintance with the subject, and certainly is not altogether without effect, namely, the fact that the dots of the different colours are sometimes superposed and sometimes side by side, according to accident in printing. This difference is not very important. The colours are arranged on the supposition that they are superposed. If otherwise, much the same tint results, but it is mixed with white, because the result is the sum of the lights instead of the sum of the absorptions. But if the dots were completely superposed, then there would be a greater area of white paper between the dots, and the white light from this source doubtless about compensates for the other. Perhaps, in the circumstances, the juxtaposition is advantageous, as the tendency for the ink last applied to show more conspicuously than the others would not hold in this case.

A notable example of the excellence that is now possible by three-colour typographic printing may be seen in "The Water-Colour Drawings of J. M. W. Turner, R.A.," a selection of fifty-eight subjects, published by Messrs. Cassell and Company, the reproductions being made by Messrs. André and Sleigh at their works at Bushey. In such a case the question that is naturally asked is, Are the colours of the reproductions similar to those of the original? Of course they are not the same pigments—this is not intended; the only aim of the printer is to give colours that cannot be distinguished from the original by simple observation. Mr. Theodore Andrea Cook, in his preface to the volume, refers to "mechanical accuracy, assisted and improved by skilfully delicate and reverentially careful handiwork," and thus sums up the position according to the facts of the case. The colours are not accurate by reason of the fact that the printing blocks are made by photographic means, although this may be claimed for the drawing—that is, the outline. In describing the process of three-colour printing, we have endeavoured to show how that imperfection and compromise qualify every step of the work. It is therefore necessary to examine the first proof by critically comparing it with the original, and then to make such alterations as are required in the three printing plates, by re-etching wholly or partially, by hand engraving, burnishing, and similar methods, continuing to make proofs and effect the needed changes until the differences are eliminated. At Messrs. André and Sleigh's this examination and hand work are carried out by trained artists, as distinguished, that is, from photographers and printers, and it is to the scrupulous care bestowed upon this adjustment of the plates by hand that the perfection of the prints depends. The justification lies in the result, and, whatever may be said for or against any principle of work, it is by the practical result only that it can, at present, be finally judged. If a copyist were to paint a copy of a picture, we should naturally seek the opinion of eminent painters as to the merits of the copy. Three-colour reproductions put forward as these are must naturally be judged in the same way, and it is a source of gratification to all interested in the technics of three-colour work to know that these reproductions have received the warm approval of many of our best known painters. But it is easy to believe that there is room for a little difference of opinion, and that a critical comparison with the originals would reveal possibilities of improvement. Such have been pointed out, and presumably no three-colour work will ever be done for which absolute faultlessness can be rightly claimed. But there is a possibility of error even in this criticism. For as the reproduction is not done in the same pigments as the original it follows that the effect of a difference of illumination will not be the same on both. If the reproduction were perfect as compared with the original by ordinary good daylight, there would probably be differences noticeable to a trained eye if they were compared on a dull day; and this probability must exist however the copy is made if the pigments used are different from those in the original. Moreover, no work in colour appears as it is intended to unless it is illuminated by the light by means of which it was produced or a quite similar light, and this is a physical law which must ever obtain.

There have been a few attempts to simplify the three-colour process by the use of one screen only, the three colours being arranged upon it. Perhaps the best known of these is due to Prof. Joly, who arranges his colours in triple parallel lines. The most recent, and the boldest in its conception, has only just been published by Messrs. Lumière. They sort out from potato starch granules from 0.015 to 0.02 mm. in diameter, and colour separate lots of these red, green, and violet respectively. When quite dry the coloured granules are mixed in such proportions that the mass appears grey, with no predominance of either colour, and a waxed glass is coated with them to form a layer only one granule thick. To prevent the interstices from passing white light, they are filled up with a fine black powder. There is next applied a varnish which has as nearly as possible the same refractivity as the starch. By this means is obtained an irregular-grained triple-colour screen. To prepare it for producing the picture it is coated with a suitably sensitised emulsion. The plate is exposed through the glass, developed, the silver image dissolved away, and the remaining silver salt reduced to the metallic state to form the image. Thus is obtained the completed transparency. It is obvious that if such plates ready for exposure were supplied commercially, the making of coloured transparencies would be much more simple than when three negatives and three prints have to be made. There must be many practical difficulties to surmount in the preparation of such compound plates, and, as in all cases of three-colour work, the process must at present be judged by the results that it yields rather than by the apparent soundness or otherwise of the theories upon which it is based.

The small volume by Mr. R. Child Bayley forms a good introduction to the subject of colour photography, as it is written in such simple language that it may be "understood and followed by any reader, even by one without the slightest acquaintance with photography," as the author states in his preface. At the same time sufficient formulæ and precise details are given for the practical working of those processes that are within the experimental possibilities of the photographer.

Chapman Jones.

NOTES.

The French physicians and surgeons who are visiting London arrived on Sunday. On Monday the president and council of the Royal College of Surgeons received the visitors, who were shown the collections in the museum. Parties have during the past three days visited the principal hospitals, general and special, the physiological laboratories of the University of London and the laboratories of the Cancer Research Fund, the Lister Institute, the Middlesex Hospital cancer department, the pathological laboratory of the County Council Asylum at Claybury, and the London School of Tropical Medicine. Receptions have been given by the editors of the *Lancet*, Dr. and Mrs. Dundas Grant, and the Dean of the Faculty of Medicine of the University of London and Mrs. Butlin. On Wednesday night the visit was brought to a close by a banquet at the Hotel Cecil.

The Government of the Federated Malay States has decided to establish an agricultural department in Malay, and has appointed Mr. J. B. Carruthers, the Government mycologist and assistant director of the Royal Botanic Gardens of Ceylon, to be director of agriculture and Government botanist. The Federated Malay States have an area of more than 25,000 square miles, and the agricultural potentialities are very promising. Large areas are being planted with rubber plants, and sugar and cocoanuts are extensively cultivated. There are two botanic gardens and a rubber experiment station in the Malay States, and all three are, we understand, to be administered by the new department.

On October 6 the Antarctic relief ship *Morning* arrived at Plymouth from Lyttelton after an absence of about two and a half years.

The first monthly general meeting of the new session of the Institution of Mechanical Engineers will be held on Friday, October 21. A paper by Mr. R. M. Neilson on "A Scientific Investigation into the Possibilities of Gas Turbines" will be read and discussed.